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Economic Sustainability of Dairy Farms in the EU

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Abstract:

Purpose: *The objective of this research is to evaluate changes in the economic sustainability of dairy farms in the European Union (EU) countries during 2007-2016 when dairy quotas were being removed in the EU. We wanted to answer the question what is the economic sustainability of dairy farms in the EU, and how has the economic sustainability in the EU countries changed after the accession of new member states in 2004 and 2017.*
Design/Approach/Methodology: *An economic sustainability assessment of farms was conducted using the Farm Accountancy Data Network (FADN) census data with several economic efficiency indicators. We analyzed variables using the Hellwig method.*
Findings: *Results indicate that milk production increased in almost all the countries of the EU, as did their economies. The largest annual increase in standard output (SO) was in Denmark, Slovakia, Czech Republic, Sweden and United Kingdom. In turn, the smallest annual increase in SO was in Lithuania, Bulgaria, Latvia and Poland. Dairy farms in the Czech Republic and Denmark had the highest economic sustainability, while dairy farms in Bulgaria, Croatia, Poland, Romania and Slovenia had the lowest economic sustainability.*
Practical Implications: *While not providing a comprehensive assessment, the indicators used do provide important information about economic impacts related to the scale and distribution of production, difference in labor cost, sources of income and maintenance of farms.*
Originality/Value: *Modern dairy farms must have production efficiency and environmental compliance to achieve sustainability. Much of the current literature focuses on the efficiency and environmental aspects of sustainability and there is a lack of data that assesses economic sustainability.*

Keywords: *Milk production, economic sustainability, dairy farms, European Union (EU).*

JEL codes: *D22, D24, O13, Q12, Q13.*

Paper type: *Research study[8].*

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1. Introduction

Agriculture is an important sector in the development of an economy in most countries. Agriculture is capable of economic growth and technological change, aiding economic development through the production of food. Moreover, agriculture plays a very important role in generating products for export and jobs for workers (Valdes and Foster, 2010; Guth *et al.*, 2020).

The main goal of an agricultural enterprise is to maximize profit. However, in order to maintain profitability, the enterprise must change and develop in a competitive market. Economic stability is a very important element of sustainability of an enterprise. Enterprises operating in a changeable environment, increasing uncertainty, and risk must look for ways that would enable them to survive and develop in a competitive market in order to achieve success.

In addition to maximize profits, the need to stabilize, sustain and develop in a competitive market is critical. It follows that economic sustainability is a very important element of successful agricultural enterprises. By adopting this approach, it is therefore most appropriate to define the sustainable, balanced and self-sustaining development of an economic entity. This concept ensures a sufficiently high income and lasting improvement on the quality of life by properly shaping the allocation among the various types of resources used on a farm. Therefore, economic sustainability should be treated as a neoclassical effective allocation and stability is by definition, measured over time (Dissart, 2003). In turn, development means achieving economic progress by generating higher income from human activities and entrepreneurship (Cieślak *et al.*, 2019). The stability achieved may result in the lack of diversification of economic activity over time. Diversity refers to the diversity of economic activities that reflects differences in economic structure. Diversity is measured in a given time (Dissart, 2003; Malizia and Ke, 1993).

2. Literature Review

The concept of "development" is complex and multidimensional in nature. It is most frequently defined as the process of positive changes, including both the quantitative growth and the qualitative progress taking place in a particular area, and relating to both the standard of living of the population and the conditions for the functioning of the business operators (Cieślak *et al.*, 2019).

The economic stability and development are both important issues for dairy farm enterprises in particular. The changing economic situations in the EU as well as access to affordable land for raising forages may be key issues for economic sustainability of dairy farms in various EU countries. The development of EU agriculture has been supported by the Common Agricultural Policy (CAP). This

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policy has changed over the years. The aim of the latest reform was to increase the competitiveness of farms in order to be more competitive overall in the world market. According to Špička *et al.* (2013), Rural Development Programme (RDP) supports the dairy improved the innovation in the EU. According to the authors the public supports, help the dairy industry to stabilize its profits and increase its competitiveness during the economic crisis.

In the years 1984-2015 one of the most important factors affecting milk production and delivery from dairy farmers to creameries within the EU was the milk quota system. The regulations helped to keep production at required levels (Boulanger and Philippidis, 2015; Alpmann and Bitsch, 2017). Eventually the EU decided to abolish the quotas system because of the increase in milk price in the world (van Kampen and Versepu, 2014). The current policy is focused on the environmental impacts of intensive agriculture; however, strong competition in the world market will force farmers towards intensification rather than extensification of production (Meyers *et al.*, 1998).

Farms which, operating in conditions of increasing environmental change and growing uncertainty and risk, must look for ways that would enable them to survive and develop in a competitive market in order to achieve success. It should be remembered that from an economic point of view, duration and development depend on the level of efficiency and financial independence of the enterprise. An enterprise contributes to more sustainable development whenever it uses each form of capital more efficiently than other companies. Regarding the micro level, this approach shows whether different forms of capital have been assigned to the enterprises that generate the highest value. At the macro level, the sustainable value approach expresses the surplus generated by the company while maintaining a constant level of capital use at the macro level. Therefore, this approach is based on the concept of strong sustainable development (Figge and Hahn, 2004, 2005; Van Passel *et al.*, 2007).

Sustainable development is a popular concept in various fields of science. There are three pillars of sustainable development: environmental protection, economic viability and social justice. However, the main focus is usually on environmental issues due to the adverse impact of human activities on the environment. Environmental issues are becoming more important while taking into consideration dynamic economic growth of the economy (Matuszczak *et al.*, 2020). This issue is particularly important to farms which have to choose between improving productivity through investment support or to limit growth but maintain compliance with environmental regulations (Czyżewski *et al.*, 2020). The sustainable development can improve the quality of life for the population and ensure sustainable food production (Guliyeva and Lis, 2020).

Many actions can be classified as sustainable or environmentally friendly (Hilden *et al.*, 2012). The definition of sustainability has been widely described. The 1990

Farm Bill described the sustainable agriculture as a system of animal and plant production which can: "(1) satisfy human food and fiber needs, (2) enhance environmental quality and the natural resource base upon which the agriculture economy depends, (3) make the most efficient use of non-renewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls, (4) sustain the economic viability of farm operations, and (5) enhance the quality of life for farmers and society as a whole" (UN, 2012).

The concept of Sustainable Development was formulated at the 2nd Managing Session of the United Nations Environment Program in 1975. It assumes "(...) such a course of inevitable and desired economic development that would not irreversibly affect the human environment and would not lead to the degradation of the biosphere, which would violate the laws of nature, economy and culture" (Holden and Linnerud, 2007; UN, 2015).

The next step was to propose and formulate in the 1987 Brundlandt Report the idea of sustainable development. The further stages of developing the idea of sustainable development were the Earth Summits in Rio de Janeiro and Johannesburg in 1992 and 2002. The most important international document agreed at the Summit in Rio de Janeiro, taking into account the issues of sustainable development, is Agenda 21 (Action Program – Agenda 21). It shows how to develop and implement sustainable development programs. According to the environmental economics, "sustainable development aims to provide all living people today and future generations with sufficiently high ecological, economic and socio-cultural standards within the limits of the natural endurance of the Earth, applying the principle of intra-generational and intergenerational justice" (Our common future, 1987, 2013; Emas, 2015).

Several papers about sustainability of dairy farms are available (Meul *et al.,* 2009; Acosta-Alba *et al.,* 2012; Czyżewski *et al.,* 2019; Nowak *et al.,* 2019). Research most often focuses on effectiveness (Wilczyński *et al.,* 2020) or determinants for the development of the dairy market (Wierzejski *et al.,* 2020). However, little attention is paid to economic sustainability. However, little attention is paid to economic sustainability. The intent of this research is to fill the gap in the literature in terms of economic sustainability.

Environmental sustainability was analyzed by Acosta-Alba *et al.* (2012). The authors have found that environmental sustainability of dairy farms is difficult to achieve and policymakers should consider less ambitious expectations. Production and consumption of milk is increasing and it requires more effective methods of production. When comparing the environmental sustainability between the EU regions it is important to note that it differs depending on the criterion we apply. Czyżewski *et al.* (2019) pointed out that public goods-oriented farming is more likely to expand after improving eco-efficiency.

Bélanger *et al.* (2012) used agri-environmental indicators to assess the dairy farm sustainability. They were divided into four components: soil quality, fertilization management, cropping practices and farmland management. Other research presents different indicators such as: climate change, water consumption, land use, agricultural subsidies and ecosystem biodiversity (Reytar *et al.,* 2014). Some research points to pesticides, herbicides, crop rotation and plant protection issues as critical factors (Czyżewski *et al.,* 2018). Boogaard *et al.* (2008) analyzed the sustainability in terms of a socio-cultural concept which contained citizens' aspects and concerns. In the literature the social aspects of sustainability can be analyzed in terms of farm labor and working conditions (Shreck *et al.,* 2006). The sustainability in economic considerations can be described by profitability, efficiency and productivity (James, 2006). However, many authors use three dimensions of sustainability combine in one index or analysis (Van Cauwenbergh *et al.,* 2007).

Läpple *et al.* (2019) measured the impact of innovation on sustainability of dairy farms. They found that innovation increased economic sustainability, and often the innovative farmers were able to achieve higher economic gains.

The current research presents a sustainability assessment based on the economic pillar of the concept of sustainable development. The economic sustainability of the farm can be measured by numbers of indicators, such as production results, income, revenue and production costs. The obtained income on a farm determines the quality of life of farmers' families and contributes to the development of farms.

The objective of our analysis was to evaluate the economic sustainability of dairy farms in the EU. The following questions were applied (1) Using the Hellwig method for analysis, what is the economic sustainability of dairy farms in the EU ? (2) How has the economic sustainability in the EU countries changed after the accession of new member states in 2004 and 2017? (3) Do the European Union Member States, differ significantly in terms of the identified measures economic sustainability?

The Hellwig method, also called the predictor optimal selection method or the information capacity indicator method, is used to select explanatory variables for the statistical model. This method is one of the commonly used taxonomic methods. It is most often used for comparative multidimensional analysis in spatial differentiation studies. A concise definition given by Hellwig says that (...) the methods and technique of comparing multidimensional objects are called multidimensional comparative analysis (...) (Hellwig, 1981). The basic aim of multidimensional comparative analysis is the construction of a synthetic measure that enables comparison of elements of a set (objects) described by means of many variables (features) and ordering them (ranking). To achieve this, linear ordering methods are most often used. The idea of linear ordering of multidimensional objects is based on the concept of a binary ordering relationship (feedback, anti-symmetrical, transient and coherent). From the axioms of this relation it follows that it is possible to determine which of any two objects in the set is the first (better) and which is the second (worse), and whether they are identical. The objects or phenomena described by many variables, whose values are measured and collected in statistical data sets, are subject to linear ordering.

On the other hand, such features of economic objects and phenomena as economic development, financial condition and utility values of products or services are variables whose values cannot be directly measured. The characteristics of these variables are based on observation functions of directly measurable diagnostic features (aggregating functions may have different analytical form). The obtained results of a synthetic variable allow to order multidimensional objects according to preferences (domination). Until now, no one has used this method to assess the economic sustainability of dairy farms (Meul *et al.*, 2009; Nowak *et al.*, 2019; Silva *et al.*, 2014). Finally, the authors of the paper prepared the Hellwig measure of dairy farms development in the EU (Table 5). To determine the direction of changes in the economic sustainability of dairy farms in EU countries, we analyzed variables based on FADN data (EC, 2018; FADN, 2019).

3. Materials and Methods

Measurement of economic stability used data from the FADN (Farm Accountancy Data Network) database for the years 2004 through 2017. Data comes from the European Commission report on dairy farms and the FADN database – The Standard Results Database (FADN, 2019). Due to the lack of data for analysis, countries such as Greece and Cyprus were not included in the evaluation. The data in these databases are collected using standard methodology for all EU countries; therefore data were used to measure the economic sustainability of dairy farms in individual countries as well as and to develop a comparative analysis among countries.

In the first stage of the analysis, we presented and compared the time course of economic size (SE005) of dairy farms in 2004-2017 in a horizontal and vertical system.

In the second stage of the analysis, we discussed the direction and dynamics of changes in the economic size (SE005) of dairy farms in the EU in 2004-2017 and pointed out the direction of changes. In this stage, historical data was used to estimate the development trend by the linear regression method of the dependent variable y (e.g. economic size) based on the value of the independent variable x (forecast of the dependent variable based on the independent variable, e.g. year). The development trend was determined using a mathematical function:

$$y=\beta_0+\beta_1+\xi, \tag{1}$$

where: β_0 and β_1 are structural parameters of the regression function, and ξ is a random component. The β_0 parameter in the linear regression equation means the so-called intercept, and the parameter β_1 is the regression coefficient of the y variable relative to the x variable. It corresponds to the directional coefficient of the linear function, so it estimates how much the value of the dependent variable y changes when the independent variable *x* changes by one unit. In the construction of the regression model, the assumption of ceteris paribus was introduced. This limited the impact of the random component ξ. The determination coefficient (r^2) is used to measure of the extent to which the model explains the formation of the y variable. In the third stage we presented the sustainability of the economic development of dairy farms based on the analysis of many variables characterizing the discussed economic entities in 2004-2016 which resulted from the availability of data (Table 1) (EC, 2018). Complex phenomena are characterized by synthetic variables to replace a set of many coefficients with one synthetic variable (Kuropka, 2001; Milenkovic *et al.*, 2014; Holgado Molina *et al.*, 2015; Pérez *et al.*, 2015; Fura and Wang, 2017).

Economic sustainability is a multidimensional concept that cannot be measured and expressed with a single variable. However, it can be characterized with the use of composite indicators. One of the oldest and most frequently used methods for determining the synthetic variable is the method developed by Zdzisław Henryk Hellwig (Hellwig, 1968; 1981; Wysocki, 2010; Pawlewicz, 2015). Many authors used this method to measure the sustainability. Bujanowicz-Haraś *et al.* (2015) used the Hellwig's method to measure the sustainable development of member states of the EU. This method allowed then to classify the states into four groups on the basis of sustainable development level. In another article sustainable development of investment in Poland was measured (Świdyńska, 2017). The implementation of sustainable development in rural gminas of Eastern Poland was also analysed (Pawlewicz *et al.*, 2016). Pomianek *et al.* (2016) used the Hellwig's method to compare semi-urban and rural gminas in Poland analysing their socio-economic development. An assessment of the social development level of rural areas using the Hellwig method also was carried out (Rząsa *et al.*, 2019). Pawlewicz (2015) measured the differences in development levels of urban gminas in Warmińsko-Mazurskie voivodeship in Poland. The gminas were ranked in terms of their level of sustainable development.

Our study was carried out in the following stages:

3.1 Choosing a Set of Variables to Determine the Productive Potential of the Dairy Sector

The selection of diagnostic variables was made from a set of potential variables that could impact economic sustainability. The most frequent measures with economic impact include productivity(including both agronomic and animal production), labor productivity, efficiency, income or profits from agricultural activity, income from sources other than a farm, production potential measured, e.g. by owned assets, etc. (Hayati, 2017). We divided the diagnostic variables into the stimulant and destimulant. The stimulant is characterized by a positive correlation with the dependent variable, an increase in the value of the dependent variable leads to an increase in the dependent variable. An increase in value means an increase in the rating, while its decrease contributes to a decrease in the rating. This is a diagnostic variable for which high values are desired.

The destimulant is characterized by a negative correlation with the dependent variable. An increase in the value of the dependent variable leads to a decrease in the dependent variable. An increase in value means a decrease in the rating, while its decrease contributes to an increase in the rating. This is a diagnostic variable for which low values are desirable. It should be emphasized that the complexity of the category of economic sustainability determined the necessity to use a set of features in research and analyzes, and their number depended on the scope of the research and was determined in the course of the subject literature and own experience. The variables were also guided by their importance in development and availability in the research period. We took the following variables to build the Synthetic Measure of Development based on the literature (Argilés and Slof, 2001; Goraj *et al.*, 2004; Goraj and Mańko, 2009) (Table 1):

Table 1. *Description of diagnostic variables.*

Variable code	Name	Unit	Unit description	Data source	Description	Role
X_1	Forage area	ha	Average forage area on the farm	SE195*	Fodder roots and brassicas (mangolds), other fodder plants, temporary grass, meadows and permanent pastures, rough grazing, fallows and set-aside land.	stimulant
X_2	Dairy cows	LU	Average number of livestock calculations per farm	SE085*	Female bovine animals (including female buffaloes) which have calved and are held principally for milk production for human consumption. Not included are cull dairy cows.	stimulant
X_3	Rented U.A.A.	%	Agricultural land leased as a% of total area	SE030*	Utilised agricultural areas rented by the holder under a tenancy agreement for a period of at least one year (remuneration in cash or in kind).	stimulant
X_4	Total labor	AWU (Annual Work Unit)	Total labor input of holding expressed in annual work units (full-time person equivalents).	SE010*	Total labor input of holding expressed in annual work units (full-time person equivalents).	stimulant
X_5	Family labor	%	% in total employment	**	The family farm labor force in the context of the farm structure survey (FSS) refers to	stimulant

					persons who perform agricultural work on the farm and are classified as the holder or family members of the sole owner.	
X_6	Milk per ha fodder area	$t*ha^{-1}$	Milk production in tonnes per ha of forage area	**		stimulant
X_7	Milk yield	kg	Milk yield of cows on average per cow	SE126*	Average production of milk and milk products (in milk equivalents) per dairy cow. Production includes farmhouse consumption and farm use (distributed to animals). Holdings without dairy cows are excluded.	stimulant
X_8	Milk production	t	Milk production in tonnes per holding	*		stimulant
X_9	Total output	€	$EUR*AWU^{-1}$ (nominal)	SE131*	Total of output of crops and crop products, livestock and livestock products and of other output. [SE135+SE206+SE256]	stimulant
X_{10}	Farm net income (FNI)	€	$EUR*AWU^{-1}$ (nominal)	SE420*	Remuneration to fixed factors of production of the family (work, land and capital) and remuneration to the entrepreneur's risks (loss/profit) in the accounting year. After deduction of the external factors of production from the farm net value added and by adding the balance of subsidies and taxes on investments, we get the remuneration of family labor, own land and own capital which can be considered as farm net income.	stimulant
X_{11}		€	Total subsidies on livestock/ Farm Net Income	SE615/SE420*	Relation of subsidies for animal production to income from a family farm	stimulant
X_{12}		LU		**	dairy cows for animals in general	stimulant

X_{13}	Tl/NW	€	Total liabilities/ Net worth	SE485/SE501*	Total liabilities to equity	stimulant
X_{14}	GIofa/NW	€	Gross Investment on fixed assets/ Net worth	SE516/SE501*	Gross investment to equity	stimulant
X_{15}	LU	€	Specific livestock costs	SE309*	Direct costs of animal production per 1 LU	destimulant

Source: ** (FADN, 2019); ** (EC, 2018).*

Variables should be treated as stimulants of economic sustainability for farms only when considering their direct impact on economic results. However, it should be emphasized that there are also interactions among them, so their indirect impact may have a different direction in relation to the direct impact on sustainability. Using the available data we wanted to choose variables which represent the economic, social and environmental dimensions of sustainability (Guth *et al.*, 2020).

In order to bring the values of variables to comparability, their normalization was performed. This procedure is necessary when using methods of statistical multivariate analysis, such as classification and linear ordering of objects. Among the factors analyzed, the variable x_{15} is a destimulant because the increase in costs may have a direct negative impact on sustainability and economic stability in both the short and long term (Vazakidis *et al.*, 2010). The higher costs of animal production have negative impact on production intensity and economic sustainability. "Indeed, the cost of purchasing many chemical and organic agents for agricultural production, with a precisely selected composition, or preparations containing a wider range of macronutrients, is higher, nevertheless too high unit inputs, regardless of their quality, exceed the absorption of the ecosystem" (Wrzaszcz, 2013).

3.2 Construction of the Taxonomic Measure of Development Using the Hellwig Measure Method

The model method of the taxonomic measure of development by Zdzisław Henryk Hellwig was used, as well as the model-free method of linear ordering to group linearly ordered objects. These methods of multidimensional comparative analysis made it possible to prioritize the studied entities, i.e. EU countries in economic sustainability. We used this method for the first time to prepare the Synthetic Measure of Development of dairy farms in the EU countries.

The starting point when constructing synthetic variables is the observation matrix, which we can present in the form:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix}, \tag{2}$$

where x_{ij} ($i = 1,2, \ldots, n$; $j = 1,2, \ldots, m$) – denotes the value of the *j*-t feature (in this case, a variable characterizing economic development) for the *i*-th object (in this case dairy farms).

Due to the fact that diagnostic variables usually have different measures, it is not possible to directly compare them. Therefore, in order to make the features comparable, normalization should be carried out, i.e. the effect of units of measurement should be eliminated. Features were normalized by standardizing them according to the formula:

$$z_{ij} = \frac{(x_{ij} - \bar{x}_j)}{s_j}, \qquad (j = 1, 2, \ldots, m), \tag{3}$$

where:

$$\bar{x}_j = \frac{1}{n} \sum_{i=1}^{n} x_{ij}, \qquad s_j = \sqrt{\frac{1}{n} \sum_{i=1}^{n} \left(x_{ij} - \bar{x}_j\right)^2}, \tag{4}$$

The result of the transformations was a matrix of standardized property values – Z:

$$Z = \begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1m} \\ z_{21} & z_{22} & \cdots & z_{2m} \\ \cdots & \cdots & & \cdots \\ z_{n1} & z_{n2} & \cdots & z_{nm} \end{bmatrix} \tag{5}$$

Based on the obtained matrix, the so-called "Development pattern", i.e. an abstract object (country) with the coordinates: $P_0=[z_{01},z_{02},\ldots,z_{0j}]$, where: $z_{0j} = \max \{z_{ij}\}$, when Z_j is a stimulant, and $z_{0j} = \min \{z_{ij}\}$, when Z_j is a destimulant. According to the considerations, it should be stated that the "development pattern" is a hypothetical country with the most favorable variable values.

The next step is to determine the Euclidean distance of each assessed object (country) Pi from the designated "development pattern" according to the formula:

$$q_i = \sqrt{\sum_{j=1}^{m} \left(z_{ij} - z_{0j}\right)^2} \tag{6}$$

On the basis of the qi values determined, the value of the synthetic Hellwig development measure was calculated, which was used to evaluate the countries studied. This value can be represented by the formula:

$$S_i = 1 - \frac{q_i}{q_0}, \qquad (i = 1, 2, \dots, n) \qquad (7)$$

where:

$$q_0 = \bar{q}_0 + 2s_0, \qquad \bar{q}_0 = \frac{1}{n}\sum_{i=1}^{n} q_i, \qquad s_0 = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(q_i - \bar{q}_0)^2} \qquad (8)$$

The synthetic measure of Hellwig S_i development generally takes values between 0 and 1. The closer its values are to 1, the higher the level of analyzed phenomenon (economic development) is characterized by the examined object (country). However, the lower the values, the lower the level of economic development of the surveyed country are. The negative value of the S_i measure may appear when the economic development of a given country is clearly weaker compared to the others.

3.3 Building a Ranking of Countries and their Division into Classes

The standard deviation and arithmetic mean of the Hellwig synthetic development measure were used to classify countries by level of economic development. Four classes have been identified (four levels of economic development) (Van Cauwenbergh *et al.*, 2007):

- class I (high level) $S_i \geq \bar{S}_i + s_{S_i}$,
- class II (medium-higher level) $\bar{S}_i \leq S_i < \bar{S}_i + s_{S_i}$,
- class III (medium-lower level) $\bar{S}_i - s_{S_i} \leq S_i < \bar{S}_i$,
- class IV (low level) $S_i < \bar{S}_i - s_{S_i}$,

where:

S_i – the value of the synthetic measure calculated using the Hellwig development pattern method,
$\bar{S}_i$ – arithmetic average of the synthetic meter S_i,
s_{S_i} – standard deviation of the synthetic meter S_i.

4. Empirical Results

4.1 Characteristics of Dairy Farms in the EU

Farms in this dataset have different amount of land. For milk production the forage area is important because it is the source for the production of fodders (Table 2). The highest forage area in 2016 was found in Slovenia (672 ha per farm), Czech Republic (265 ha.), Estonia (174 ha), Sweden (112 ha) and United Kingdom (109 ha). The lowest forage area was found in 2016 in Romania (2 ha), Malta (4 ha), Croatia (12 ha), Slovenia (16 ha) and Poland (15 ha).

During the years 2007-2016 four countries decreased their forage area: Hungary (-50%), Malta (-20%), Slovakia (-14.4%), Austria (-7.7%). The biggest increase of forage area in the years 2007-2016 was observed in Bulgaria (133%), Sweden (60%), Spain (47,1%) and Denmark (43%). The changes in dairy farms in the EU have been characterized by large reductions of dairy farm numbers. Many dairy farms have increased size and adopted new technologies and more intensive systems. Moreover, many dairy farms have acquired more productive cows and introduced concentrated diet (Alvarez and del Corral, 2010). Such changes in dairy farms have been observed in the USA, too. The changes have led to the increase of cow yields.

However, the demand for milk and dairy products did not keep pace with production increases, which resulted in imbalances between supply and demand (Mosheim and Lovell, 2009). These changes resulted in lower prices, that forced farmers to improve efficiency and productivity (Abdulai and Tietje, 2007).

Milk production and cow breeding can be described as strategic in relation to arable land and permanent grassland. Cattle breeding represents a crucial condition to maintain a balance between the plant production and breeding processes of agricultural business activities, its environmental impact is also significant (Siničáková, 2012; Simo *et al.*, 2016).

We have also analyzed the number of cows per dairy farm in the EU (Table 2). The highest number of cows per dairy farm in 2016 was observed in Slovakia (215 cows), Denmark (160 cows), United Kingdom (130 cows), Estonia (99 cows) and Netherlands (90 cows). The fewest number of cows in dairy farms in 2016 was observed in Romania (4), Lithuania (11), Croatia (13), Bulgaria (14), Austria and Poland (both 18).

The average number of cows decreased in Hungary (-42.3%) and Malta (-10.4%) in the years 2007-2016. Cow numbers were not changed in Romania. The highest increase of cows in dairy farms was observed in the years 2007-2016 in Belgium (100.0%), Estonia (62.3%), Sweden (61.5%), Luxemburg (57.1%) and Spain (47.1%).

We wanted to recognize the state and changes of total labor-annual work unit (AWU) in dairy farms in the EU. The highest total labor was found in 2016 in Slovakia (27.0), Czech Republic (15.7), Estonia (5.4), Hungary (3.2) and United Kingdom (2.7). The lowest total labor-AWU was found in Romania (1.0), Ireland (1.6), Lithuania, Netherland and Portugal (1.7).

The highest decrease of total labor – AWU was found in Hungary (-55.5), Romania (-44.4), Slovakia (-24.2), Malta (-11.5) and Portugal (-10.5). The highest increase of total labor in the years 2007-2016 was found in Denmark (31.8), Sweden (23.8) and Spain (18.8).

Table 2. *Characteristics of dairy farms in the EU*

Country	Forage area of dairy farms in the EU (ha)				Average number of cows (LU)				Total labor (AWU)			
	2004	2007	2016	2007/2016 (%)	2004	2007	2016	2007/2016 (%)	2004	2007	2016	2007/2016 (%)
EU28	-	22	30	36.4		23	33	43.5		2	2	0
Austria	27	26	24	-7.7	16	16	18	12.5	1.7	1.6	1.8	12.5
Belgium	36	40	50	25	45	48	70	45.8	1.6	1.6	1.8	12.5
Bulgaria	3	3	7	133	7	7	14	100	1.8	1.8	1.9	5.6
Croatia		-	12	-		-	13	-		-	2.1	-
Czech Republic	186	209	265	26.8	94	108	154	42.6	12.9	14	15.7	12.1
Denmark	62	79	113	43	87	117	160	36.6	1.9	2.2	2.9	31.8
Estonia	137	146	174	19.2	48	61	99	62.3	5.6	5.9	5.4	-8.5
Finland	26	31	43	38.7	21	25	35	40	2.1	2.1	2.1	0
France	57	61	75	23	43	46	59	28.3	1.8	1.8	1.9	5.6
Germany	42	45	57	26.7	44	47	66	40.4	1.9	1.9	2.1	10.5
Hungary	33	76	38	-50	29	71	41	-42.3	3.0	7.2	3.2	-55.5
Ireland	50	56	62	10.7	47	55	73	32.7	1.6	1.6	1.6	0
Italy	24	19	26	36.8	42	40	50	25	2.1	2	1.8	-10
Latvia	34	39	40	2.6	12	14	18	28.6	2.2	2.3	2.1	-8.7
Lithuania	17	21	23	9.5	8	10	11	10	1.6	1.9	1.7	-10.5
Luxemburg	61	68	80	17.6	39	42	66	57.1	1.7	1.7	1.8	8.9
Malta	4	5	4	-20	56	67	60	-10.4	2.2	2.6	2.3	-11.5
Netherlands	40	44	50	13.6	65	70	90	28.6	1.6	1.6	1.7	6.3
Poland	7	11	15	36.4	13	13	18	38.5	1.8	1.8	1.9	5.5
Portugal	14	15	17	13.3	23	26	32	23.1	1.8	1.9	1.7	-10.5
Romania	2	2	2	0	4	4	4	0	1.8	1.8	1	-44.4
Slovakia	577	785	672	-14.4	181	212	215	1.4	36.1	35.6	27	-24.2
Slovenia	13	13	16	23,1	13	13	19	46.2	2.2	1.9	1.8	-5.3
Spain	15	17	25	47.1	30	17	25	47.1	1.4	1.6	1.9	18.8
Sweden	70	70	112	60	43	52	84	61.5	2.0	2.1	2.6	23.8
United Kingdom	79	94	109	16	93	112	130	16.1	2.3	2.5	2.7	8

Note: *LU – average number of livestock calculations per farm; AWU – total labor input of holding expressed in annual work units (full-time person equivalents).*
Source: *Own elaboration on the basis of EU FADN (EC 2018).*

Milk yield per ha of fodder area is an important measurement of efficiency and productivity (Table 3). The highest milk yield per ha of fodder area was observed in 2016 in: Malta (99.3), Spain (17.6), Netherlands (15.0), Latvia and Lithuania (2.8) and Czech Republic (4.5). The highest increase of milk yield per ha of fodder area from 2007-2016 was observed in Estonia (78.6), Latvia (47.4), Slovakia (43.8) Luxemburg (43.2) and Malta (38.5). The greatest decrease of milk yield per ha of fodder area was observed in the years 2007-2016 in Bulgaria and Czech Republic (both -31.5), Romania (-23.5) and Italy (-0.7).

The economic development of dairy farms depends on milk yield per cow (Table 3). A milk yield increase on dairy farms was observed in most countries of the EU in the years 2007-2017, except Bulgaria (-22.1%), Romania (-10.4%) and Netherlands (-2.1%). The biggest increase of milk yield per cow in the years 2007-2016 was observed in Estonia (34.8%), Czech Republic (29.9%), Denmark (22.0%), Latvia (20.3%) and Slovakia (20.1%). The yield of milk is diversified in the EU.

According to EU FADN the highest milk yield per cow in 2017 was observed in Denmark (10,043 kg/cow), Estonia (9,161 kg/cow), Sweden (8,822 kg/cow), Finland (8,819 kg/cow) and Spain (7,903 kg/cow). The lowest milk yield in dairy farms in 2017 was observed in: Bulgaria (3,000 kg/cow), Croatia (4,297 kg/cow), Romania (3,382 kg/cow), Lithuania (5,522 kg/cow) and Slovenia (5,687 kg/cow).

One of the most important problem of milk production is decreased fertility. It is the results of rising production and larger numbers of animals per worker (Borawski *et al.*, 2020). The profitability of dairy farms can be improved by new technologies, better nutrition, herd management and advances in genetics (Stelwagen *et al.*, 2013). It is recognized that the old EU members have more specialized dairy farms and their share is about 95% (Kroupova, 2016).

Table 3. *Milk production in dairy farms in the EU.*

Countries	Milk per ha fodder area				Milk yield per cow (1000kg/cow)			
Country	**2004**	**2007**	**2016**	**2007/2016 (%)**	**2004**	**2007**	**2016**	**2007/2016 (%)**
EU28		7.8	8.4	7.7		6.5	7.1	8.9
Austria	3.7	3.9	5.3	35.9	6.3	6.5	7.2	11.5
Belgium	7.5	8	-	-	6.1	6.7	7.6	13.4
Bulgaria	6.3	8.9	6.1	-31.5	3.9	3.9	3.0	-22.1
Croatia		-	5.2	-	-	-	4.3	-
Czech Republic	3.0	3.2	4.5	-31.5	5.8	6.3	8.2	29.9
Denmark	11.0	12.1	13.3	9.9	7.9	8.2	10.0	22
Estonia	2.0	2.8	5	78.6	5.7	6.8	9.2	34.8
Finland	6.6	6.9	7.3	5.8	8.1	8.6	8.8	2.5
France	4.7	4.9	5.5	12.2	6.3	6.6	6.9	4.6
Germany	7.1	7.4	8.8	18.9	6.8	7.1	7.5	5.5
Hungary	5.0	6.4	9.3	45.3	6.1	6.9	7.1	2.1
Ireland	5.0	5.3	6.7	26.4	5.3	5.4	6.4	17.9
Italy	11.4	14.1	14	-0.7	6.6	6.7	7.4	10.4
Latvia	1.6	1.9	2.8	47.4	4.6	5.2	6.3	20.3
Lithuania	2.2	2.4	2.8	16.7	4.6	5.1	5.5	7.6
Luxemburg	4.5	4.4	6.3	43.2	7.1	7.2	7.9	10
Malta	57.2	71.7	99.3	38.5	5.1	5.8	6.2	7.4
Netherlands	12.2	12.4	15	20.7	7.5	7.8	7.6	-2.1
Poland	8.0	6.2	7.1	14.5	4.8	5.0	6.1	20.4
Portugal	10.2	11.5	14.2	23.5	6.1	6.8	7.7	12.7
Romania	4.3	6.8	5.2	-23.5	3.8	3.8	3.4	-10.4
Slovakia	1.5	1.6	2.3	43.8	5.3	5.9	7.0	21.1
Slovenia	5.5	5.8	6.7	15.5	5.2	5.5	5.7	4
Spain	9.9	13.2	17.6	33.3	6.0	6.8	7.9	15.7
Sweden	4.9	6.2	6.8	9.7	8.0	8.4	8.8	5.5
United Kingdom	8.0	8.5	8.6	1.2	6.8	7.1	7.5	5.5

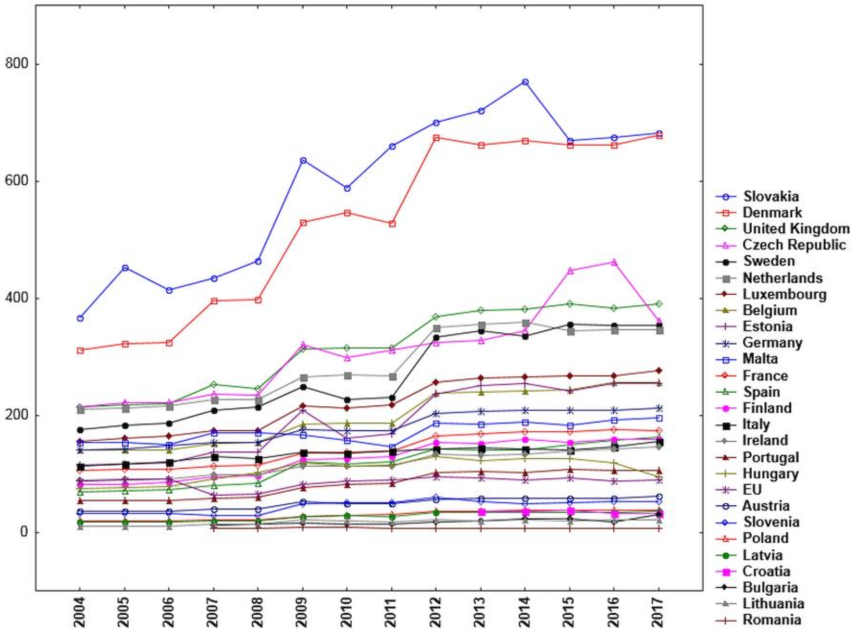
Source: *Own study on the basis of EU FADN (EC. 2018).*

4.2 The Economic Development of Dairy Farms from 2004 to 2017 in EU

The economic development of dairy farms can be measured by the total standard output (SO – SE005=total standard output in €/1 000). The community typology defines the (economic) size of an agricultural holding on the basis of its potential gross production (total standard output) (EC, 2019). It includes all the plant and animal production on the farm. The EU dairy farms are diversified in terms of total output (coefficient of variation 88.75%), which was the lowest in 2017 in: Romania (€ 7), Lithuania (€ 20.7), Bulgaria (€ 31.1), Croatia (€ 32,3), Latvia (€ 36,2) and Poland (€ 36,8). The highest total standard output in dairy farms in this time was found in Slovakia (€ 681,2), Denmark (€ 677,6), United Kingdom (€ 390,5), Czech Republic (€ 360,3), Sweden (€ 352,4) and Netherlands (€ 346,4). The total output in dairy farms has increased in the years 2004-2017 in all countries of the EU (Figure 1). The average growth for the EU was € 85.6k however, it should be added that in 2007-2008 the standard output (SO)value dropped to around € 62k.

In the entire EU, the change in the SO level in the years of the analysis was only 1.14%. The highest growth rates were in the following countries from 2004 to 2017: Bulgaria (165.81% only data from 2007 to 2017), Spain (132.66%), Estonia (121.68%), Denmark (117.25%), Sweden (100.34%) and Latvia (100%). In turn, the lowest growth was observed in Romania (18.6%), Malta (26.9%), Hungary (29.4%), Italy (37.8%), and Germany almost 50%. It should be added that among the analyzed countries Croatia was the only country with a decrease in SO in the analyzed period by almost 9% (here there will be a dynamic attachment in "Supplementary Files").

Figure 1. *Economic size of dairy farms in UE in 2004-2017 (SE005=total standard output in thousand €, the lines are sorted like a legend).*



During the analysis, 2004-2017, the economic size of dairy farms in virtually all EU countries had an upward trend (Table 4). However, it should be noted that the SO level volatility indicators in the analyzed EU countries are characterized by low or average volatility. The largest annual increase can be seen in countries such as Denmark (€ 33.4), Slovakia (€ 28), Czech Republic (€ 17.2), Sweden (€ 16.5) and United Kingdom (€ 16.2). In turn, the lowest annual increase in SO was observed in Lithuania (€ 0.9), Bulgaria (€ 1.4), Latvia (€ 1.7) and Poland (€ 1.7). Only this indicator for the entire EU and Croatia and Romania does not show statistical significance, therefore it is not possible to present the direction of changes (here also an attachment to the dynamic drawing).

Table 4. *Basic statistics and direction of changes in the economic size of dairy farms in the EU in 2004-2017 (SE005 = total standard output in thousand €).*

	Valid N	r	r^2	p	SE	CV	Regression equation	↑/↓
EU	14	0.352	0.124	^0.218	2.604	11.380	y = -1559.9169 + 0.8185*x	-
Denmark	14	0.946	0.895	0.000	39.440	28.080	y = -66561.9629 + 33.3686*x	↑
Slovakia	14	0.879	0.772	0.000	35.593	22.661	y = -55644.4527 + 27.9692*x	↑
Czech Republic	14	0.903	0.816	0.000	21.294	25.803	y = -34279.3332 + 17.2037*x	↑
Sweden	14	0.946	0.895	0.000	19.511	27.294	y = -32917.709 + 16.5059*x	↑
United Kingdom	14	0.962	0.926	0.000	18.788	22.465	y = -32196.1936 + 16.1697*x	↑
Netherlands	14	0.932	0.868	0.000	16.372	21.493	y = -27138.2057 + 13.64*x	↑
Estonia	14	0.932	0.869	0.000	15.639	30.915	y = -26019.6807 + 13.036*x	↑
Belgium	14	0.964	0.929	0.000	12.519	23.786	y = -21496.1455 + 10.7899*x	↑
Luxembourg	14	0.968	0.938	0.000	12.426	21.233	y = -21419.76 + 10.7629*x	↑
Spain	14	0.971	0.943	0.000	9.176	29.525	y = -15908.504 + 7.9705*x	↑
Finland	14	0.960	0.921	0.000	8.393	25.111	y = -14361.1477 + 7.2053*x	↑
France	14	0.966	0.933	0.000	7.603	20.064	y = -13062.5525 + 6.5677*x	↑
Germany	14	0.963	0.927	0.000	7.456	15.586	y = -12733.7053 + 6.4226*x	↑
Portugal	14	0.953	0.908	0.000	5.927	27.027	y = -10073.4053 + 5.0512*x	↑
Ireland	14	0.980	0.961	0.000	5.538	17.796	y = -9644.8732 + 4.8552*x	↑
Hungary	14	0.723	0.523	0.004	5.285	18.644	y = -6767.1945 + 3.4187*x	↑
Malta	14	0.812	0.660	0.000	4.566	9.984	y = -6499.3127 + 3.3178*x	↑
Italy	14	0.950	0.903	0.000	3.283	9.101	y = -5473.6679 + 2.7897*x	↑
Austria	14	0.944	0.890	0.000	2.562	19.526	y = -4297.564 + 2.162*x	↑
Slovenia	14	0.805	0.648	0.001	2.828	23.848	y = -4048.2112 + 2.0356*x	↑
Poland	14	0.956	0.914	0.000	2.036	26.060	y = -3469.4833 + 1.7402*x	↑
Latvia	14	0.952	0.907	0.000	1.994	27.109	y = -3386.7936 + 1.6982*x	↑
Bulgaria	11	0.870	0.756	0.001	1.681	30.516	y = -2922.9055 + 1.4618*x	↑
Croatia	5	-0.697	0.486	^0.191	1.106	7.126	y = 2231.05 - 1.09*x	-
Lithuania	14	0.878	0.770	0.000	1.124	24.410	y = -1756.4301 + 0.8822*x	↑
Romania	11	-0.113	0.013	^0.740	0.184	8.993	y = 48.8691 - 0.0209*x	-

Note: *Valid N — number of available monthly data included in the regression analysis; SE—standard error—the average difference between the actual values of the dependent variable and the predicted values by the model; CV—coefficient of variation, p>0.05, ^ lack of significance.*
Source: *Own study.*

4.3. The Hellwig Measure of Economic Sustainability of Dairy Farms in the EU

The main goal of the farm is to maximize profit; however, the farm must also continue to develop in a competitive market. Therefore, economic sustainability is a very important element of the functioning of the farms. This also applies to farms that are operating in the conditions of increasing environmental change, increasing uncertainty, and risk. The results indicate that the group of farms in the mentioned countries shows the highest economic stability. Economic sustainability improves and ensures a steady income and reduces the economic fragility of farms and helps to guarantee relative stability.

The first high level of economic sustainability (red col our) was achieved by dairy farms in Czech Republic and Denmark. Dairy farms from Slovakia and Sweden were in the first group too. However, their position fluctuated between the first and second class in the analyzed period. Slovak dairy farms are mainly cooperatives with large dairy herds and high yield, that increase their efficiency.

The second-class medium-higher level (orange colour) was achieved by dairy farms from Belgium, Germany, Luxemburg for all the analyzed time. The economic sustainability of countries such as the Netherlands, France and United Kingdom has fallen from first class to second class. In countries such as Estonia, Finland, Italy and Malta, on the other hand, moved from the third class.

Table 5. *Hellwig measure of dairy farms economic sustainability in the EU.*

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Austria	0.087	0.074	0.066	0.077	0.081	0.078	0.074	0.073	0.078	0.084	0.097	0.092	0.074
Belgium	0.200	0.189	0.189	0.198	0.192	0.199	0.201	0.192	0.200	0.201	0.225	0.223	0.187
Bulgaria				0.033	0.038	0.047	0.052	0.033	0.064	0.073	0.066	0.073	0.044
Croatia										0.039	0.038	0.052	0.043
Czech Republic	0.212	0.234	0.218	0.218	0.223	0.236	0.253	0.247	0.232	0.229	0.272	0.299	0.268
Denmark	0.344	0.293	0.280	0.296	0.247	0.194	0.220	0.252	0.269	0.289	0.336	0.264	0.263
Estonia	0.164	0.164	0.203	0.186	0.209	0.198	0.190	0.207	0.236	0.225	0.231	0.105	0.155
Finland	0.166	0.162	0.148	0.164	0.162	0.191	0.188	0.180	0.163	0.153	0.148	0.136	0.166
France	0.230	0.232	0.204	0.215	0.222	0.226	0.217	0.214	0.219	0.213	0.235	0.237	0.208
Germany	0.179	0.150	0.159	0.178	0.163	0.174	0.168	0.167	0.169	0.182	0.193	0.191	0.172
Hungary	0.099	0.121	0.109	0.156	0.151	0.120	0.151	0.196	0.142	0.128	0.161	0.138	0.131
Ireland	0.114	0.075	0.076	0.111	0.110	0.092	0.099	0.104	0.099	0.110	0.138	0.139	0.124
Italy	0.113	0.125	0.119	0.128	0.123	0.129	0.119	0.124	0.136	0.133	0.170	0.165	0.150
Latvia	0.060	0.052	0.065	0.083	0.092	0.080	0.072	0.095	0.106	0.108	0.102	0.109	0.104
Lithuania	0.023	0.029	0.037	0.067	0.071	0.076	0.070	0.067	0.060	0.073	0.076	0.091	0.092
Luxemburg	0.192	0.157	0.150	0.180	0.171	0.171	0.152	0.179	0.195	0.197	0.222	0.224	0.184
Malta	0.191	0.202	0.184	0.188	0.198	0.183	0.165	0.140	0.145	0.138	0.179	0.183	0.195
Netherlands	0.229	0.238	0.245	0.228	0.225	0.210	0.208	0.201	0.207	0.204	0.240	0.224	0.186
Poland	0.034	0.022	0.031	0.051	0.050	0.033	0.036	0.040	0.041	0.047	0.059	0.060	0.054
Portugal	0.098	0.095	0.086	0.112	0.099	0.118	0.119	0.121	0.119	0.119	0.136	0.140	0.124
Romania				0.000	-0.015	-0.012	-0.015	-0.019	-0.031	-0.011	-0.007	0.000	0.005
Slovakia	0.211	0.213	0.218	0.155	0.193	0.208	0.229	0.221	0.189	0.186	0.190	0.310	0.303
Slovenia	0.054	0.050	0.037	0.046	0.038	0.050	0.054	0.063	0.057	0.053	0.063	0.064	0.058
Spain	0.107	0.105	0.085	0.112	0.107	0.111	0.100	0.112	0.111	0.114	0.142	0.142	0.146
Sweden	0.229	0.205	0.209	0.220	0.233	0.254	0.219	0.233	0.227	0.215	0.217	0.244	0.238
United Kingdom	0.237	0.207	0.203	0.223	0.214	0.216	0.198	0.194	0.188	0.202	0.225	0.202	0.187

Legend:

Class I (high level)	Class II (middle-higher level)	Class III (middle-lower level)	Class IV (low level)

Source: *Own research.*

The third class or medium-lower class level is marked with blue colour. Such countries as Austria, Ireland, Portugal and Spain achieved this level. On the other hand, the situation improved in Latvia and Lithuania (from IV class to II). Economic sustainability in Hungary fluctuated – in 2007-2008 and 2010-2011 and 2014 this country was in second class, however, in the remaining years there has been a decrease to the third class.

The fourth class is characterized by the greatest economic instability of dairy farms. The fourth class is the weakest (low level of development) and it was attained by dairy farms from Bulgaria, Croatia, Poland, Romania and Slovenia. Dairy farms in these countries have not their economic sustainability much and did not move to a higher class.

Dairy farms operate in a competitive market and are under globalization pressure (Krpalkova *et al.*, 2016). The financial crises in the world, increased demand for dairy products from emerging economies impact a dairy farm's success in the global economy.

Our analysis confirmed that dairy farms from Czech Republic gained much from their accession to the EU. According to Kroupova (2016) the new members of the EU had the growth in milk yield, the reduction in the number of cows and world market price development. As a result, the increase of milk production in specialized dairy farms has been observed. These economic occurrences can be seen in many countries, especially those which joined the EU in 2004, but the processes were the strongest in the Czech Republic dairy farms.

5. Conclusions

The assessment of economic sustainability of farms was based on FADN census data. From 2004 to 2017, the efficiency of dairy farms as measured by milk yield per cow improved in almost all countries of the EU with the exception of Romania. Milk production contributes to food security, economic development, stability and social equality and social ties for dairy farm families. The combination of these functions leads to both social and economic stability of farms within communities. The economic sustainability of dairy farms depends on in part on access to land area for growing forage for dairy cattle feed. Access to forage area is diverse among EU countries, and the largest increases in forage area for 2007-2016 were in Bulgaria, Sweden, Spain and Denmark. Dairy farms in in the Czech Republic and Denmark showed the highest economic sustainability while dairy farms in in Bulgaria, Croatia, Poland, Romania and Slovenia showed the lowest economic stability.

This study contributes to the existing knowledge of economic sustainability of farms specializing in milk production. The developed conceptual model can stimulate discussion and research into the problem of maintaining economic sustainability. The proposed procedure can be used at different levels of decision-making for economic and environmental policies and to build strategies that promote sustainable development (Siničáková, 2012; Simo *et al.*, 2016).

The factors determining the possibility of farms' sustainability in economic aspects, include the economic size and type of farming. The obtained results showed that the higher economic potential of dairy farms allows for agricultural production at a higher level of sustainability. These finding is also supported by the literature (Wrzaszcz, 2013).

The European Union Member States differ in terms of the identified measures economic sustainability. The find the difference we used the Hellwig method. Our analysis confirmed that the highest level of economic sustainability was typical by dairy farms in Czech Republic, Denmark, Slovakia and Sweden. Dairy farms in these countries had big changes in terms of farm area, dairy herds and economic size. Slovakia (215 cows), Denmark (160 cows) and Czech Republic (154) had the highest number of cows per dairy farm in 2016. Dairy farms in these countries improved the profitability using new technologies, herd management and advances in genetics and better nutrition (Stelwagen *et al.,* 2013). The production potential of dairy farms had a positive effect on their economic sustainability (Wrzaszcz, 2013). The lowest economic stability of dairy farms was characterized by dairy farms from Bulgaria, Croatia, Poland, Romania and Slovenia. Dairy farms in these countries encounter problems in development including small possibility to increase farm area and dairy herd, lower cow's yields and fertility (Borawski *et al.*, 2020). Romania (4), Lithuania (11), Croatia (13), Bulgaria (14), Austria and Poland (both 18) had the fewest number of cows in dairy farms in 2016.

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